

1 SOLID-STATE IMAGE PICKUP APPARATUS WITH FAST PHOTOMETRY
WITH PIXELS INCREASED, AND SIGNAL READING OUT METHOD
THEREFOR

5 **BACKGROUND OF THE INVENTION**

Field of the Invention

10 The present invention relates to a solid-state image pickup
apparatus with fast photometry with pixels increased and a
signal reading out method therefor. More particularly, the
invention relates to a solid-state image pickup apparatus,
which includes an array of photosensitive cells integrated
in higher density and arranged obliquely adjacent to each other,
that is, in the co-called honeycomb structure having the lines
or rows of cells offset from each other by a length equal to
15 the half of the pitch of the cells in line or row, to accomplish
an increased resolution, and which is advantageously applicable
to an electronic still camera, an image input apparatus and
the like.

20 **Description of the Background Art**

With reference to a solid-state image pickup apparatus
taking the so-called honeycomb arrangement, various proposals
have been disclosed in, for example, Japanese patent publication
No. 31231/1992, and Japanese patent laid-open Nos. 77450/1994
25 and 136391/1998.

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As
In the apparatus disclosed in Japanese patent publication
No. 31231/1992, first electrodes meander along photosensitive
cells which are arranged in the offset manner, so as to form
a wavy shape pattern, and second electrodes are formed in
another wavy pattern opposite in phase to the former. Other
photosensitive cells are arranged in a region where the first
and second electrodes separate so as to enable a signal to

1 be read out from each cells via means for selectively coupling
with the second electrodes, in response to an enable signal
supplied to the first electrode, thus further increasing the
5 resolution and the sensitivity of the solid-state image pickup
apparatus from conventional. In the publication, the
photosensitive cells is exemplified as formed octagonal.

10 In Japanese patent laid-open publication No. 77450/1994,
the shape of photosensitive cells is formed as a square which
is one of diamond shapes, and each side thereof forms an angle
of 45 degrees in a vertical direction, so that its aperture
ratio is made to be high, thus miniaturizing the solid-state
image pickup apparatus. Particularly, by adopting a honeycomb
15 arrangement, an increase in a vertical resolution is achieved.
Moreover, a micro-lens is disposed on each photosensitive cell,
thus increasing a light receiving efficiency.

20 In Japanese patent laid-open publication No. 136391/1998,
meandering charge transfer devices of two lines are arranged
between photoelectric conversion devices in a column direction,
which are disposed so as to be adjacent to each other in the
same row and relatively shifted by approximately the half of
the interval between themselves in the adjacent rows, and
the charge transfer devices are used for transferring the charge
25 from the photoelectric conversion devices obliquely adjacent
to each other. A spurious signal aliasing such as moiré is
suppressed while achieving a high-density integration of the
photoelectric conversion devices and an increase in a
photoelectric conversion efficiency.

30 In this case, color filter segments are arranged in the
form of Bayer arrangement rotated by 45°. In this color filter
arrangement, color G is arranged in an isotropic relation to
color R/B in both row and column directions. Also, a honeycomb

1 stripe pattern is used, where the same number of color filter
segments for colors R, G and B are uniformly arranged. In
this case, the shape of the color filter segments are a regular
5 hexagon and set in a relationship where the center distances
between adjacent photosensitive cells are all equal.

In the foregoing Japanese patent publication No. 31231/1992
and Japanese patent laid-open publication No. 77450/1994,
attention is paid only to the structure of the device in aiming
10 at a high-density integration. Moreover, in Japanese patent
laid-open publication No. 136391/1998, descriptions for the
structure and the shape of the device and the positional
relation of the color filters are made. Then, descriptions
of whole-pixel reading out using these relations are made.

15 By the way, it is apprehended that a high-density
integration takes times for a reading out of signal charge
obtained by a photoelectric conversion. For example, in a
mode of controlling a light measurement or a photometry in
20 which an automatic focus adjustment (AF) and an automatic
exposure (AE) control are performed, there are demands for
shortening a time required for reading out the signal charge
and for finishing a preparation for an image pickup without
delay. For photosensitive cells, the high-density integration
25 of the image pickup devices and shortening of the time of the
signal reading out are antinomic demand, which are contradictory
to each other.

30 Particularly, when the signal is read out from the
photosensitive cells adopting a honeycomb arrangement in the
mode of controlling a light measurement, a breakthrough by
a different method from conventional methods is needed.

In particular, to perform Automatic Exposure (AE) control

1 or Automatic White Balance (AWB) adjustment, information on
all colors is necessary, and single-color reading out as in
the case of Automatic Focus adjustment (AF) is useless. High-
speed signal reading out timed with a drive signal is desired
5 when the image capturing with the AE and AWB controls is
performed.

SUMMARY OF THE INVENTION

10 It is therefore an object of the present invention to
provide a solid-state image pickup apparatus capable of
performing, for instance, AE control faster than conventional
signal reading out by means of an image signal containing all
colors used for color separation in photosensitive cells
arranged in a honeycomb-like structure, and to provide a signal
15 reading out method therefor.

20 In a solid-state image pickup apparatus capable of
performing, for instance, AE control by means of an image signal
containing all colors used for color separation in
photosensitive cells arranged in a honeycomb-like structure,
and signal reading out method therefor, a digital still camera
supplies a signal in a mode set by a mode setting section to
a system control section. Upon receiving the signal, the system
control section controls a drive signal generation section
25 to generate a drive signal. Incident lights are supplied onto
an image pickup section through a color separation filter having
filter segments of identical colors arranged in a column
direction. The image pickup section photoelectrically converts
the lights incident to the respective photosensitive cells.
30 A drive signal generated by the drive signal generation section
according to the specified mode is supplied to a signal reading
out gate, so that an transfer for the signal charges is
performed. In this case, signals for all the colors are read
out in response to the drive signal in compliance with the

1 color filter arrangement of the color separation filters.
The signals read out are used by AF and AE adjustment sections
for appropriate controls.

5 Accordingly, in an application in which much more
photosensitive cells are integrated, time required for signal
reading out can be shortened without any color limitations.
Thus, the solid-state image pickup apparatus is advantageously
applicable to, for instance, AE or AWB adjustment control which
10 requires a reduction in signal reading out time.

A signal reading out method of the present invention
includes the steps of selecting a whole-pixel reading out mode
of reading out signal charges from all the pixels or a thinning
15 reading out mode for reading out signal charges after thinning,
generating a drive signal for reading out the signal charges
according to the selected mode, selecting a destination to
which this drive signal is supplied, and then supplying the
signal to the destination. An incident light is separated
20 into at least three colors, and the incident light separated
in the color in the color separation step is received by each
of a plurality of photosensitive cells.

After this image pickup step, especially in the thinning
25 reading out mode, only signal charges generated by the
photosensitive cells of a line to be read out among the
plurality of photosensitive cells are field-shifted in response
to the drive signal. Thereafter, signal charges are transferred
in a column direction in compliance with the arrangement of
30 color filters for color separation. Then, after the signal
charges are shifted in line, the signal charges "EMPTY" of
column where neither pixel mixing nor signal reading out occurs
are synthesized to combine signals read out from a plurality
of the photosensitive cells. By transferring the line-shifted

1 signal charges in a horizontal direction, compared with signal
reading out in the whole-pixel reading out mode, reading out
of the signal charges of all the colors can be completed within
a very short time.

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BRIEF DESCRIPTION OF THE DRAWINGS

The objects and features of the present invention will
become more apparent from consideration of the following
detailed description taken in conjunction with the accompanying
10 drawings in which:

FIG. 1 shows a way of connecting FIGS. 1A and 1B with
each other;

FIGS. 1A and 1B are schematic block diagrams, which show
in contribution an exemplified constitution of a solid-state
15 image pickup apparatus of the present invention applied to
a digital still camera;

FIG. 2 is a schematic plan view useful understanding the
relationship between the vertical transfer paths and
photosensitive cells arranged in the form of a honeycomb in
the image pickup device of FIG. 1A, when viewing from its light
20 incident side;

FIG. 3 is a schematic plan view showing an arrangement
of color separating filters adopting a honeycomb type G square
lattice RB complete checkered pattern, in which the color
separation filters are arranged integrally with each other
25 on the light incident side of the image pickup device shown
in FIG. 1A;

FIG. 4 is a schematic plan view showing the connections
of the photosensitive cells, signal reading out gates, transfer
30 devices on the vertical transfer paths and horizontal transfer
paths, and drive signals supplied to them;

FIG. 5 is a timing chart showing a vertical synchronous
signal, a vertical timing signal and a transfer gate signal
when a whole-pixel reading out is performed by the drive signal

1 generator shown in FIG. 1B;

FIG. 6 is a timing chart showing the vertical synchronous signal, the vertical timing signal and the transfer gate signal with the leading edge portion of the vertical synchronous signal of FIG. 5 is depicted in an enlarged scale;

FIG. 7 is a timing chart illustrating the vertical synchronous signal, a horizontal synchronous signal, the vertical timing signal, the transfer gate signal, a drive signal and a potential generated by the drive signal in the vicinity of a leading edge portion of the horizontal synchronous signal shown in FIG. 6 in an enlarged scale;

FIG. 8 is a timing chart useful for understanding the phase relationship between the vertical timing signals used for generating signals of a four-phase drive in the image pickup device shown in FIG. 1A;

FIG. 9 is a timing chart depicting the vertical synchronous signal, the horizontal synchronous signal, the vertical timing signal and the transfer gate signal, which are generated by a signal generator when signal charge only for a color G is read out in the image pickup device shown in FIG. 1A in a mode of controlling a light measurement;

FIG. 10 is a schematic plan view useful for understanding the positional relationship of the photosensitive cells from some of which signal charges are actually read out and from the others of which no signal charges are read out in response to the supplied transfer gate signals shown in FIG. 9;

FIGS. 11A, 11B and 11C are schematic plan views, which illustrate the states of field shift, vertical transfer and horizontal transfer, respectively, in signal-charge reading out operated in response to a drive signal supplied based on the signal of FIG. 9 generated by the signal generator;

FIGS. 12A and 12B schematically illustrate vertical and horizontal transfers, respectively, carried out after the signal reading out of FIG. 11C;

FIGS. 13A and 13B schematically illustrate the states of vertical and horizontal transfers in a process improved from the thinning of FIGS. 11A - 12B;

FIG. 14 is a schematic view illustrating a state continuing from the improved thinning process of FIGS. 13A and 13B;

FIG. 15 is a timing chart useful for understanding a timing relationship when 1/4 thinning is performed in a vertical direction in the image pickup device of the digital still camera in the photometry control mode;

FIG. 16 is a timing chart useful for understanding the relationship between a vertical synchronous signal, vertical timing signals and transfer gate signals in the vicinity of the positive-going edge of the vertical synchronous signal of FIG. 15 in an enlarged scale;

FIG. 17 is a timing chart useful for understanding relationship between the vertical synchronous signal, the horizontal synchronous signal, the vertical timing signals and the transfer gate signals in the vicinity of the positive-going edge of the horizontal synchronous signal of FIG. 16 in an enlarged scale;

FIGS. 18A, 18B and 18C schematically illustrate the transferring processes of the 1/4 thinning in a vertical direction shown in FIG. 15 and the improved type of thinning (1/2) shown in FIGS. 13A and 13B;

FIGS. 19A and 19B are schematic views useful for understanding the flow of signal charges in the image pickup device after the transfer of FIG. 18C;

FIGS. 20A to 20D are schematic views useful for understanding the transferring process of the 1/4 thinning in a vertical direction shown in FIG. 15 and the improved type of thinning (1/4) including pixel mixing carried out twice; and

FIGS. 21A, 21B and 21C are a schematic views useful for understanding the flow of signal charges in the image pickup

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device after the transfer of FIG. 20D.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 Next, description will be made of a preferred embodiment of a solid-state image pickup apparatus in accordance with the present invention with reference to the accompanying drawings.

10 A solid-state image pickup apparatus of the present invention includes an image pickup device having an array of photosensitive cells integrated in the form of honeycomb arrangement, and requires a shorten period of time for reading out a signal than that for the whole-pixel scheme in order to achieve a high speed automatic control of AE and AWB by
15 using all the colors of the primary or complementary color filters, for example. A noteworthy feature of the solid-state image pickup apparatus is its capability of performing the automatic control as fast as conventional by reading out signals from specified photosensitive cells even in the honeycomb arrangement employed.
20

25 Description will now be made of a case where the solid-state image pickup apparatus of the present invention is applied to a digital still camera 10. Parts having no direct relations with the present invention are not shown, and description thereof will be omitted. Signals are designated with the same reference numerals as connecting lines on which the signals are conveyed.

30 As shown in FIGS. 1A and 1B, the digital still camera 10 includes an image pickup system 10A, a signal processing system 10B, a drive signal generation section 10C, a signal output system 10D, a mode setting section 10E and a system control 12.

1 *IMS*
AF The image pickup system 10B includes an optical lens 102,
an image pickup device 104, an AF control 106 having a focusing
mechanism and an AE control 108 having an aperture mechanism.
In addition to these elements, although not shown, to completely
5 shut off an incident light, a shutter mechanism may be included
in an incident light side of the image pickup device 104.
The optical lens 102 is an optical system for focusing the
incident light from an object field on a photosensitive array
of the image pickup device 104.

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The image pickup device 104 includes an array of
photosensitive cells 104a arranged two-dimensionally in a
honeycomb-like manner in row and column directions such that
the photosensitive cells 104a for performing photoelectric
15 conversion for supplied incident lights form a light receiving
plane (see FIG. 2). In the honeycomb-like structure, the
respective photosensitive cells 104a are shifted or offset
from other photosensitive cells obliquely adjacent thereto
by a length equal to the half of the pitch thereof in the row
20 and column directions. The honeycomb-like structure does not
mean the shape of the photosensitive cell. It should be noted
that the pitch means, for example, the distance between the
centers of the adjacent two photosensitive cells in the row
or column direction. In the image pickup device 104, on the
25 surface of the photosensitive cells 104a, a single plate of
color separation filter CF is formed integrally to separate
colors of the incident light, which correspond to the respective
photosensitive cells 104a. The arrangement of the color
separation filter CF causes an incident light to be separated
30 in color to have the respective color attributes of primary
colors RGB to be received by the respective photosensitive
cells 104a.

As shown in FIG. 3, because of the integral structure,

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1 this relationship of colors is represented by symbols R, G
and B indicating colors in the respective photosensitive cell
104a. The same color filter segment R, G or B of FIG. 3 is
5 aligned in the vertical direction as in the stripe form. Thus,
this color filter arrangement is called a honeycomb type stripe
pattern. The image pickup device 104 outputs an image signal
10a to the signal processing system 10B.

10 In the illustrative embodiment shown and described above,
the single plate of color separation filter CF is of the
honeycomb type primary color RGB columnar striped pattern
composed of the RGB filter segments. The present invention
is however not restricted to the specific type of color filter
15 described above but advantageously applicable to other filter
systems of complementary colors, such as the honeycomb type
three-color GYeCy columnar striped pattern in which for the
color filter segments R, G and B of the honeycomb type primary
color RGB columnar striped pattern, replaced are the color
filter segments of Yellow Ye, green G and cyan Cy, respectively,
20 and the honeycomb type three-color, Gray or W and YeCy columnar
striped pattern in which for the color filter segments Ye,
G and Cy of the honeycomb type three-color GYeCy columnar
striped pattern, replaced are the color filter segments of
yellow Ye, gray Gray or white W, and cyan Cy, respectively.

25 The constitution of the image pickup device 104 will be
further described. The image pickup device 104 operates in
response to a drive signal 122a output from the drive signal
30 generation section 10C. Each of the photosensitive cells 104a
is constituted by a charge coupled device (hereinafter referred
to as CCD). As shown in FIG. 4, each of the photosensitive
cells 104a is provided with a signal reading out gate or
transfer gate 104b connected to a transfer device adjacent

thereto, specifically the vertical transfer device. The signal reading out device 104b is adapted to block the signal charge converted from the incident light from leaking. The signal reading out gates 104b transfer the signal charge from the photosensitive cells 104a to vertical transfer paths 104c in response to a field shift pulse supplied through the electrodes. The vertical transfer paths 104c transfer sequentially the signal charge read out in the column direction, that is, in the vertical direction. The signal charge is supplied to transfer devices in line direction, that is, horizontal transfer path 104d, through line shifting. In response to a drive signal, the horizontal transfer path 104d outputs this signal charge to the signal processing system 10B through an amplifier 104e as described above.

Here, in each of the vertical transfer paths 104c, three transfer devices are disposed between adjacent two of the photosensitive cells 104a when viewing in the vertical direction (column direction). The four transfer devices, including the transfer devices connected to the associated signal reading out gates 104b, are used for transferring data of a pixel in one line. Thus, it is proved that four-phase drive signals are supplied as the drive signal for one line transfer. Each of the signal reading out gates 104b is disposed between one of the photosensitive cells 104a and one of the vertical transfer paths 104c.

Furthermore, since the arrangement of the photosensitive cells in the honeycomb-like manner is adopted in which the respective photosensitive cells are shifted from other photosensitive cells obliquely adjacent thereto by the half of pitch in the row and column directions, between adjacent two vertical transfer devices 104c in question, the signal reading out gates 104b are disposed in such a manner that one

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1 is shifted from the other in the vertical direction by a distance equal to the two transfer devices of the vertical transfer paths 104b.

5 Specifically, when the relation in the arrangement between the two vertical transfer paths 104c is observed, the photosensitive device of color G corresponds in level to the vertical transfer device V1 in the vertical direction, the photosensitive device of color R to the vertical transfer device
10 V3, the photosensitive device of color G to the vertical transfer device V5, and so on. The basic constitution of the image pickup device 104 has been described above. With such constitution, the whole-pixel reading out is performed normally. Thus, the signal charge of all of the photosensitive cells
15 is read out at a time.

Returning to FIG. 1A, the AF control 106 adjusts the focal position of the optical lens 102 so as to be brought at the optimum position in accordance with information obtained by
20 measuring the distance between an object and the camera 10 by the focus adjustment mechanism (not specifically shown). At this time, an estimation of the information concerning the distance measurement and a control amount from the information concerning the distance measurement are processed by the system
25 control 12. As a result, in response to the control signal 12a supplied, the AF control 106 drives the focus adjustment mechanism in response to the drive signal 106a, so as to move the optical lens 102 along its optical axis in the direction of the arrow A.

30 Furthermore, the AE control 108 permits the aperture or iris of the aperture mechanism to be displaced under the control of an exposure control (not shown) provided in the system control 12 adapted to estimate the amount or intensity of the

1 measured light from the object field including the object,
thus adjusting the amount of luminous flux incident onto the
photosensitive array. The measurement of light is performed
5 using a part of the image pickup signal. Also in this case,
the exposure amount is calculated by the system control 12,
based on the amount of measured light. The system control
12 supplies to the AE control 108 the control signal 12a for
use in controlling the aperture value and the shutter speed
10 value so as to mate with the calculated exposure amount. The
AE control 108 supplies a drive signal 108a to the aperture
mechanism and the shutter mechanism in response to the control
signal 12a so as to adjust those mechanisms to the aperture
value and the shutter speed value. This adjustment will
optimize the exposure.

15 The signal processing system 10B of FIG. 1B comprises
a pre-processor 110, an A/D converter 112, a signal processor
114, a buffer 116 and a compressor/decompressor 118. The pre-
processor 110 performs, for example, a correlated double
20 sampling (CDS) for signal charge 10a supplied thereto to reduce
noises, and performs a gamma correction for the signal 10a.
The pre-processor 110 amplifies the signal 10a. Thus, the
amplified signal 10a is output to the A/D converter 112.

25 The A/D converter 112 samples the analog signal 10b
supplied from the image pickup device 104 through the pre-
processor 110, in response to a clock signal 120b supplied
from the signal generator 120, which generates also a timing
signal 120a, and using the control signal 12b from the system
30 control 12, and quantizes the analog signal 10b, thus converting
the signal 10b to a digital signal 10c. The resultant digital
signal 10c is supplied to the signal processor 114.

The signal processor 114 performs the automatic exposure

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1 control, the white balance control (AWB: Automatic White
Balance control) and the aperture correction for the signal
10c supplied, and then performs a signal processing in
5 accordance with the two modes. Specifically, these two modes
are directed to the modes set by a shutter release button 128
of a mode setting section 10E, described later, namely, a still
picture shoot mode in which an obtained still image data is
transferred to a storage 126 of a signal output system 10D,
and simply a light control mode in the automatic focusing (AF)
10 of the image pickup system 10A. A gamma correction may be
performed in this stage or in a later stage.

15 In the digital still camera 10, which mode is to be
selected is controlled by the control signal 12b from the system
control 12. In the still picture shoot mode, under the control
of the system control 12, the signal processor 114 performs
a digital signal processing, such as the broadening of the
band of the luminance signal on the signal which has been
undergone the foregoing signal processing.

20 On the other hand, in the mode of controlling a light
measurement, taking into account that the supplied signal 10c
is digital, the system control 12 is adapted to perform a
control such that the signal from the image pickup device 104
25 is read out faster than the conventional reading-out rate,
and process the signal read out. In addition, the vertical
thinning down of the lines is performed so as to allow the
display 124 of the signal output system 10D to display the
image representative of the image signal. The signal processor
30 114 performs a signal processing in the still picture shoot
mode so as to convert the digital image signal 10c to a
recordable video signal. Then, the signal processor 114 outputs
to the buffer 116 the signal 10d in the mode in which a
display/record is selected.

1 The buffer 116 has a function to amplify the video signal
10d supplied from the aforementioned signal processor 114 with
a predetermined gain as well as to perform a control on its
time axis in recording. Under the control of a recording
5 control (not shown) arranged in the system control 12, the
buffer 116 outputs the picture signal 10e either to the signal
output system 10D or to the compressor/decompressor 118 or
both.

10 In recording the picture, the compressor/decompressor
118 takes a picture signal 10e thereinto in response to the
control signal 12b of the system control 12. The supplied
picture signal 10e undergoes a compression based on, the Joint
Photographic coding Experts Group (JPEG) standard, for example.
15 When the signal 10f recorded is read out from the storage 126,
the signal 10f is subjected to a signal processing such as
a conversion reverse to the foregoing compression processing,
whereby the original picture signal is reproduced. The restored
picture signal (not shown) is supplied to the display 124 and
20 displayed thereon.

 The drive signal generation section 10C includes the signal
generator 120 and a driver 122. The signal generator 120
generates synchronous signals 120b based on clock signals
25 locally oscillated so as to drive the digital still camera
10 in, for example, a present broadcast system (NTSC/PAL) and
supplies the signal 120b to the signal processor 114. The
signal generator 120 supplies the signal 120b as clock signals
for use in generating a sampling signal and a read/write signal
30 to the pre-processor 110, the A/D converter 112, the buffer
116 and the compressor/decompressor 118.

 The signal generator 120 generates the synchronous signals
from the locally oscillated clock signals, and, using these

1 signals, generates a variety of timing signals 120a. The
generated timing signals 120a include timing signals used for
reading out the signal charge excited in the image pickup device
104, such as, vertical timing signals which define timings
5 for driving the vertical transfer paths, horizontal timing
signals which define timings for driving the horizontal transfer
paths and timing signals which are used to perform field shift
and line shift. Moreover, the signals from the signal generator
120 are also used for controlling operations of the AF control
10 106 and the AE control 108. The lines conveying those signals
are not illustrated apparently.

Thus, the various kinds of signals are output to the
foregoing circuit components, and the signal generator 120
15 supplies the vertical timing signals and the horizontal timing
signals to the driver 122. When the control signal 12b in
the mode of controlling a light measurement (photometry mode)
is supplied from the system control 12 to the signal generator
120, the signal generator 120 supplies a signal for elevating
20 the substrate voltage of the photosensitive cells, that is,
an overflow drain voltage for the photosensitive cells of the
colors R and B, according to demand, for example, in the mode
of controlling a light measurement. The supply of this signal
enables a signal reading out prohibited state to be set.

25 For example, in the photosensitive cell of colors R and
B, a state is set which is similar to one where no signal
charges are generated at all. In the photometry mode, the
signal generation section 120 generates a transfer gate signal
30 to read out signal charges from a photosensitive cell that
has received a signal reading out permission. When the
photometry mode is selected, the signal generation section
120 selectively switches the timing signals in response to
the control signal 12b from the system control 12. The driver

1 122 generates a drive signal 122a at the supplied timings.
Generally, to change a signal reading out speed, a vertical
5 drive signal output from the driver 122 in a selected mode
is supplied to the image pickup device 104, so that a drive
for the entire photosensitive array, a drive for selected colors
and a drive based on the thinning rate of pixels are performed.

The driver 122 outputs a corresponding drive signal 122a,
especially when the mode is set to the photometry mode. To
10 change a drive signal level appropriately for a mode, a level
switch is provided to perform the switching. Generally, a
voltage level is selected from 1V, 5V, 8V and 12V in the
illustrative embodiment. The driver 122 generates a drive
15 signal 122a timed with the timing signal 120a supplied from
the signal generation section 120. The driver 122 generates
a tri-state drive signal from the vertical timing signal and
the transfer gate signal.

The signal output system 10D includes the display 124
20 and the storage 126. In the display 124, a liquid crystal
display monitor of the VGA (Video Graphics Array) standard
supplied with inputs of digital RGB signals is provided. The
storage 126 is adapted to store the video signal 10f supplied
to a magnetic recording medium, a semiconductor memory used
25 for a memory card, an optical recording medium or a magneto-
optical recording medium. Moreover, the storage 126 is also
capable of reading out the video signal 10f thus stored so
to be displayed on the display 124. With the type of storage
126 in which the recording medium is detachably mounted the
30 recording medium may be detached so as to reproduce the video
signal recorded on the recording medium by an external apparatus
to display and/or print the picture.

The mode setting section 10E includes a release button

128 and key switches 130. In this embodiment, a two-stroke button mechanism is provided in the release button 128. Specifically, in the half-depressed state as the first stroke, the photometry mode is set to develop a signal representing the photometry mode set to the system control 12. In the fully-depressed state as the second stage, the signal defining the timing for taking the picture is supplied to the system control 12 to notify the system control 12 of fact that the picture recording mode, or the still picture shoot mode, was selected. The settings of these modes are reported to the system control 12 on a signal line 28. Furthermore, when the shutter release button 128 is in its state of powering the camera 10 on and a switch (not shown) of the image monitoring display is in its ON state, the system control 12 based on the signal supplied through the release button 128 controls the display 124 so as to display a moving picture in the moving picture mode.

The key switches 130 is a cross-shaped key, which selects items and picture images by moving a cursor in all directions (e.g. up-/down-ward/right-/left-ward), which is displayed on the screen of the display 124. The selected information is also sent to the system control 12 on a signal line 30. Especially, the key switch 130 selects a thinning rate of pixels set to 1/2, 1/4 or 1/8 in the photometry mode, and supplies the selected thinning rate to the system control 12. This setting prescribes for the way of reading out signal charges used for AE and AWB in the photometry mode.

The system control 12 is adapted for controlling the general operation of the camera. The system control 12 includes a central processing unit (CPU). The system control 12 decides, based upon the input signal 28 from the release button 128, which mode is selected. Furthermore, the system control 12 controls the processing on the picture signal of the camera

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1 by selection information 30 from the key switches 130 as
described above. Based on the supplied information, the system
control 12 controls the operation of the drive signal generation
section 10C based on the supplied information. The system
5 control 12 includes a recording control (not shown). The
recording control controls operations of the storage 126 of
the signal output system 10D and the buffer 116 in response
to a timing control signal 12c from the system control 12.

10 Now, the operation of the digital still camera 10
constructed as discussed above will be described. First,
description will be made on the whole-pixel reading out usually
carried-out. The digital still camera 10 is normally provided
with the image pickup device 104 capable of performing whole-
15 pixel reading out. Thus, if an indication of the still picture
shoot mode is produced by the release button 128, a light
incident through the color separation filter CF of the honeycomb
type stripe pattern is received by the entire photosensitive
array. Each photosensitive cell 104a performs photoelectric
20 conversion upon having received the light, and then accumulates
signal charges.

To read out the accumulated signal charges from the
photosensitive cells 104a, as shown in FIG. 5, the signal
25 generation section 120 generates a vertical synchronous signal
VD. Also, the signal generation section 120 generates vertical
timing signals V_1 to V_8 to be supplied to the transfer devices
 V_1 to V_4 and V_5 to V_8 of the vertical transfer path 104c and
transfer gate signals TG_1 , TG_3 , TG_5 and TG_7 to be supplied to
30 the signal reading out gate 104b in synchronization with the
vertical synchronous signal VD. FIG. 5 schematically shows
that in each vertical synchronization period of time, the
vertical timing signals V_1 , V_4 , V_5 and V_8 are negative signals,
and the vertical timing signals V_2 , V_3 , V_6 and V_7 are positive

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1 signals. It can be understood that the transfer gate signals
TG₁, TG₃, TG₅ and TG₇ are generated to read out signal charges
in synchronization after the inputs of the vertical synchronous
5 signal VD from each photosensitive cell. The timing
relationship can be understood from FIG. 6, which is enlarged
in time axis.

More specifically, in this stage, signal charges are read
out only from the photosensitive cell in a position associated
10 with the vertical timing signals V₁ and V₅ when the transfer
gate is switched ON, and no field shift is carried out until
a next vertical synchronous signal is supplied (also see FIG.
5). Then, after field shift, the vertical timing signals are
supplied in sequence in synchronization with a horizontal
15 synchronous signal HD. The supply of these signals causes
the signal charges shifted to the vertical transfer path 104c
to be transferred toward the horizontal transfer path 104d.

FIG. 7 shows in an enlarged scale the timings of the
vertical timing signals and the transfer gate signals after
20 the vertical synchronous signal VD has been changed to its
level "H" and the horizontal synchronous signal HD has risen
in the timing relations of FIG. 6. Especially, after the
vertical timing signals V₁ and V₅ and the transfer gate signals
TG₁ and TG₅ have been supplied to the driver section 122,
25 vertical drive signals ϕV_1 and ϕV_5 are output to the image pickup
device 104. Subsequently, potentials shown in FIG. 7 are formed
in the vertical transfer devices V1 and V5. Since the transfer
gate signals TG₃ and TG₇ are also switched ON, vertical drive
signals ϕV_3 and ϕV_7 are generated. Accordingly, the potentials
30 are formed as shown in FIG. 7.

FIG. 8 is a timing chart showing how the signal charges

1 shifted to the vertical transfer path 104c are transferred
toward the horizontal transfer path 104d. The vertical transfer
path 104c is indicated in the form of vertical transfer devices
V1 to V8. It can understood that two identical vertical drive
5 signals are supplied respectively to the vertical transfer
devices V1 to V4 and the vertical transfer devices V5 to V8.
In other words, driving is performed by four signals having
different phases. After the line shift has been performed
for the vertically transferred signal charges, signal charges
10 of all the pixels are read out from the image pickup device
104 at once within a specified period of time by transferring
the horizontal transfer paths 104d in sequence.

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15 Consideration is now given to typical image pickup
operations procedures of the digital still camera 10. First,
in the digital still camera 10, a photometry or light
measurement is performed for an object field before an image
pickup. To pick up an image of the object field, the release
button 128 is depressed to its half stroke, thus setting the
20 photometry mode. In this case, to perform AF adjustment
control, only color G from signals obtained by the photoelectric
conversion in the image pickup device 104 of the image pickup
system 10A is extracted. This is because the information of
color G, occupying about 70% of the luminance information,
25 is only necessary for performing the AF adjustment control.
In the light measurement in the auto focusing AF, pixel
information must be repeatedly read out until an appropriate
value is detected. Thus, there is a request for reading out
signal charges at a speed as high as possible.

30 On the other hand, to perform AE and AWB adjustment
control, as information about all colors is necessary, such
single color reading out is not sufficient, but rather all
color components of the color separation are used. More

1 detailed description will be made later of the ways of
generating and supplying the drive signal 122a and performing
high-speed signal reading out in connection with driving of
the image pickup device 104 when the AE and AWB adjustment
5 control is performed according to the embodiment. As described
above, in the photometry mode, reading out of single color
G and thinning and reading out of all the colors are carried
out.

10 The picture signal 10a obtained by the image pickup system
10A following the light measurement is then supplied to the
signal processing system 10B under the control of the system
control 12. In the signal processing system 10B, the supplied
picture signal 10a is converted into a digital signal 10c by
15 the A/D converter 112 through the pre-processor 110. The image
data 10c obtained by the conversion is then supplied to the
system control 12 in the form of light measurement information,
although not shown. The system control 12 uses this light
measurement information for further processing. In the
20 processing, the system control 12 generates control signals
12a for AE control and also for AF control, and outputs these
control signals respectively to the AF and AE control 106 and
108. The AF and AE control 106 and 108 perform the AF and
AE controls in response to the control signals 12a supplied
25 through the respective mechanisms incorporated therein. These
adjustments are carried out repeatedly in the above mode.

Then, the user further depresses the release button 128
to its full stroke at a desired image shooting timing. At
30 this time, a signal recording for an image of the object field
is supplied to the system control 12. As in the case of the
previous mode, the image pickup system 10A performs image pickup
for a light incident from the object field. In this still
picture shoot mode (the whole-pixel reading out), however,

1 processing for taking out all the colors is carried out in
the image pickup device 104 without any pixel thinning. Before
the image pickup, needless to say, a drive signal to be supplied
is different from that in the previous signal reading out.

5

The picture signal 10a produced is converted into a digital
signal 10c by the A/D converter 112 of the signal processing
system 10B, and then supplied to the signal processor 114.
The signal processor 114 performs a signal processing on the
10 image data corresponding to a luminance signal and a color
difference signal so as to be extended to a higher frequency
band. Then, obtained image data 10d is supplied through the
buffer 116 to the compressor/decompressor 118. The
compressor/decompressor 118 performs a compression on a signal
15 10f, and outputs the compressed signal to the signal output
system 10D. In the still picture shoot mode, the image data
10f of all the pixels supplied under the control of the
recording control section in the system control 12 is recorded
in the storage 126. The storage 126 will develop the recorded
20 image data under the control of the recording control section.

Thus, the digital still camera 10 can be used for both
of the photometry mode and the still picture shoot mode by
manipulating release button 128. In the digital still camera
10, including an image pickup device having a large number
of pixels exceeding one million, in the still picture shoot
mode, time necessary for reading out the all pixels of an image
signal is not such a big problem except when continuous shooting
is carried out. But in the photometry mode, as described above,
25 reading out time needs to be shortened when AE or AF control
is performed. Next, description will be made of operations
of the image pickup device 104 and the drive signal generation
section 10C in the photometry mode for performing AE control
in the digital still camera 10 by using the image pickup system
30

1 10A having the above-described specifications.

5 *TNS*
PH 4 As the honeycomb type stripe pattern is employed for the
color separation filters CF, it can be understood from FIG.
to the vertical transfer devices V1 and V5, and the
photosensitive cells 104a of color G are adjacent to the
vertical transfer devices V3 and V7. In this case, the transfer
gate signals TG₃ and TG₇ are supplied to make the signal reading
out gates 104b adjacent to the vertical transfer devices V1
and V5 is switched to the OFF state thereof, and the signal
reading out gates 104b adjacent to the vertical transfer devices
V3 and V7 is switched to the ON state thereof. These timing
relations are shown in FIG. 9. The other transfer gate signals
15 TG₁ and TG₅ are at "H" levels. Accordingly, the signal readi
ng out gates 104b adjacent to the vertical transfer devices
V1 and V5 are in the OFF states thereof, so that signal charges
of colors R, G and B cannot be read out. These relations are
indicated by the hatched pixels of reading out prohibited lines
of signal charges and reading out permitted lines of signal
charges shown in FIG. 10.

20
Because of the above relations, as shown in FIG. 11A,
signal charges are read out from the photosensitive cells R1,
25 G1, B1, R2, G2, B2, and so on, to the vertical transfer paths
104c. The signal charges read out to the vertical transfer
paths 104c are then transferred in sequence toward the
horizontal transfer path 104d as described above. At this
time, all the signal charges in the vertical transfer paths
30 104c are moved in the lower direction by transfer distances
corresponding to two lines. As a result, the signal charges
of the photosensitive cells R1, G1 and B1 closest to the
horizontal transfer path 104d are supplied to the horizontal
transfer path 104d.

1 Accordingly, the signal charges of the photosensitive
cells R1, G1 and B1 are moved by two lines, but the movements
thereof in the second lines are line-shifted. Since no signal
charges are read out from the photosensitive cells indicated
5 by hatched lines, a transfer device in the horizontal transfer
path 104d which the signal charges should have entered is
indicated by symbol E (emptiness or lack of signal charge),
see FIG. 11B. Then, the signal charges E, R1, E, G1, E, B1,
and so on, that have reached the horizontal transfer path 104d
10 are transferred in sequence to the amplifier 104e arranged
on the output side (not shown in FIG. 11), and output from
the latter. Subsequently, all the signal charges remaining
in the vertical transfer paths 104c are moved in the lower
direction again by two lines (see FIG. 12A). Then, the signal
15 charges E, R2, E, G2, E, B2, and so on, that have reached the
horizontal transfer path 104d, are transferred in sequence
toward the amplifier 104e arranged in the output side, and
output from the latter (see FIG. 12B).

20 By the above-mentioned transfer of the signal charges,
the signal charges only from the photosensitive cells indicated
by the hatched lines in FIG. 10 are read out. In the
arrangement of FIG. 10, the 1/2 thinning is carried out both
in the horizontal and vertical directions. However, this
25 arrangement employs the honeycomb-like structure as described
above, where the pitches of pixel shifting are offset by 1/2
in the vertical and horizontal directions. Thus, the number
of actually read out pixels is not equal to the number of pixels
of the 1/4 thinning of all the pixels, even when the 1/2
30 thinning is performed both in the vertical and horizontal
directions. Reading-out of the signal charges to the vertical
transfer device is not carried out, so that by dealing with
that element of the device as "E" in this transfer device, the
signal charges can be processed exactly like actual signal

1 charges.

5 In other words, in the vertical transfer, these signal charges "E" can be ignored, whereas in the transfer of a horizontal direction, transfer is carried as if the signals "E" had signal charges "E" occupying the positions of one transfer device. Accordingly, the number of the transfer stages through which the horizontal transfer is made is the same as that of the transfer stages encountered when no thinning is carried out (see FIGS. 11C and 12B).

15 Thus, the inventor studied the way of reading out signal charges to perform the 1/2 thinning also in the number of transfer stages in the horizontal direction. The procedures are as follows. As shown in FIG. 11A, signal charges are read out. Then, in the vertical transfer also, all the signal charges read out on a two-line (two-stage) basis are transferred in the same manner as in the case shown in FIG. 11B. Thus far, the procedures are the same as those in the previous procedures.

20 Then, in the horizontal transfer, the signal charges are moved by two stages on the transfer path 104d in the horizontal direction. For this reason, the horizontal transfer path 104d has a structure capable of holding at least extra transfer devices equivalent to two stages to hold the signal charges. In this case, as a line of signals not to be read out is provided, a transfer device equivalent to one stage only needs to be added. As a result, the signal charges of colors R, G and B are sent directly below the vertical transfer paths for transferring "E" (see FIG. 13A). Then, the same vertical transfer as that described above is carried out by two lines. In this way, the remaining signal charges are transferred in the lower direction by two stages. Areas "E" exist in positions

1 where the colors R1, G1 and B1 were located before the transfer,
i.e., directly below the vertical transfer paths. Signal
charges R2, G2 and B2 are vertically transferred to the
5 positions of "E" by two lines (see FIG. 13B). In both FIGS.
13A and 13B, even if the signal charges are transferred to
the positions indicated by signal charges "E" no mixing occurs
between "E" and any one of transferred colors R, G and B.
Accordingly, the signal charges of colors R1, R2, G1, G2,
10 B1 and B2 are held without being mixed.

As a result, the signal charges of colors R, G and B
equivalent to two lines are housed in the horizontal transfer
path 104d of FIG. 13B. In the horizontal transfer after the
second vertical transfer, all the signal charges R1, R2, G1,
15 G2, B1, B2, and so on, of two lines of the color are read out
at once from the horizontal transfer path 104d. This transfer
processing enables the signal charges equivalent to two lines
to be read out within the time period of usual one-line reading
out (see FIG. 14). In other words, the 1/2 thinning is carried
20 out in the horizontal direction.

By the foregoing procedures, the 1/2 thinning is performed
both in the horizontal and vertical directions. Accordingly,
compared with the time for the whole-pixel reading out, required
25 time can easily be shortened by 1/4. It may be advisable to
prevent any signal charges from remaining in the transfer paths
by performing high-speed transfer before reading out.

To perform the 1/4 thinning for reading out of all the
30 pixels, for example, as shown in FIG. 15, a pulse is applied
to the transfer gate signal TG₇. In response to this pulse,
the signal reading out gate is switched ON for one line. This
situation of FIG. 15 is shown more specifically in FIGS. 16
and 17, which are timing charts showing a horizontal synchronous

1 signal HD in an enlarged scale.

5 A drive signal thus obtained from the transfer gate signal TG₇ is supplied to the image pickup device 104. Upon having received the drive signal, first, as shown in FIG. 18A, paying attention to the photosensitive cells adjacent to each other in two lines, for example, transfer gate signals TG₁ and TG₃ are supplied to the line of color G of the left end adjacent to color R, and transfer gate signals TG₅ and TG₇ are supplied to the line of color R held between colors G and B. In this relation, if the transfer gate signal TG₇ is supplied, to drive each four photosensitive cells arranged in two lines, signal charges accumulated by light receiving are read out only from one photosensitive cell. At this stage, the signal reading out has been done to a quarter of the entire pixels. The further transfer in the vertical (column) direction is carried out in the lower direction on a two-stage basis in the vertical transfer paths 104c (see FIG. 18B).

20 The signal charges supplied to the horizontal transfer path 104d are transferred toward the output side on a two-stage basis (see FIG. 18C). After this transfer, vertical transfer is carried out by two stages (see FIG. 19A). In this way, the signal charges equivalent to four lines in amount are stored altogether in the horizontal transfer path 104d. The stored signal charges are then read out to a next horizontal transfer path (see FIG. 19B). By such horizontal transfer, the 1/2 thinning is performed by reading out from two lines at once. For this signal reading-out, the thinning results in $1/4 \times 1/2 = 1/8$ considering the overall transfer in the horizontal and vertical directions. From the four transfer gate signals, one may be selected.

1 In the foregoing example, the rate of thinning in the
horizontal direction was $1/2$. Next, description will be made
of a process of transfer where thinning in the horizontal
5 direction is set to $1/4$ which is the same as in the case of
the rate of thinning in the vertical direction. As shown in
FIG. 20A, by supplying a pulse of the transfer gate signal
TG₇, signal charges of colors R₁, G₁, B₁, and so on, and colors
of R₃, G₃, B₃, and so on, are read out to the respective
10 vertical transfer paths 104c. It may be advisable to completely
prevent any charges from remaining in the transfer paths by
performing high-speed transfer before reading out of these
signal charges.

15 In the initial vertical transfer, the signal charges in
the vertical transfer paths 104c are transferred by two stages.
As a result, colors R₁, G₁, B₁, and so on, are supplied to
the horizontal transfer path 104d (see FIG. 20B). Subsequently,
the vertical transfer based on a process different from the
conventional process is carried out. In other words, all the
20 signal charges remaining in the vertical transfer paths 104c
are transferred by four stages. By this transfer, the signal
charges of colors R₃, G₃, B₃, and so on, are supplied to the
horizontal transfer path 104d. In the transfer devices of
the horizontal transfer path 104d directly below the vertical
25 transfer paths 104c from which the signals have been read out,
the signals of identical colors, i.e., colors (R₁+R₃), (G₁+G₃)
and (B₁+B₃), are combined (see FIG. 20C). At this time, in
the transfer devices of the horizontal transfer path 104d
directly below the vertical transfer paths 104c from which
30 no signal charge reading-out has been carried out, no changes
occur with "E" added. From the horizontal transfer path 104d,
the stored signal charges are transferred toward the output
side by two stages (see FIG. 20D).

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1 For vertical transfer thereafter, transfer of four stages
is repeated by twice. In the first transfer, as shown in FIG.
21A, the signals of colors R5, G5 and B5 are supplied to the
horizontal transfer path 104d. In the next second transfer,
5 the signals of colors R7, G7 and B7 are supplied to the
horizontal transfer path 104d. In this way, in the transfer
devices which have received the signal charges by the first
transfer, the signals of identical colors, i.e., colors (R5+R7),
(G5+G7) and (B5+B7), are synthesized (see FIG. 21B). By such
10 signal synthesizing of the identical colors, the thinning in
the transfer of the horizontal direction will result in 1/4
in total by further thinning the signal charges by 1/2 in the
horizontal direction. After the signal synthesizing, all the
signals stored in the horizontal transfer path 104d are output.
15 For this signal reading out, the thinning results in $1/4 \times$
 $1/4 = 1/16$ for all the pixels.

20 With the above-described constitution, the present
situation in which the trial to meet the demand for a high
integration of the photosensitive array obstructs antinomically
the high-speed reading out of the signal charge can be
comparatively easily solved by accurately reading out all the
colors to be used. Thus, the present invention can be used
for the AE and AWB control which requires the fast reading
25 out of the signal charge from the image pickup device. Since
the image pickup section serves as a light measurement sensor,
a dedicated light measurement sensor can be omitted.

30 The entire disclosure of Japanese patent application No.
20068/1999 filed January 28, 1999 including the specification,
claims, accompanying drawings and abstract of the disclosure
is incorporated herein by reference in its entirety.

